Long-term Acoustic Assessment of Bats at Powderhouse, South Dakota for 2015-2017

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Prepared by:

Dan Bachen, Braden Burkholder and Bryce Maxell

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Background

We established a long-term, ultrasonic acoustic monitoring site on BLM lands in northwestern South Dakota (Figure 1), following deployment and maintenance protocols in Maxell (2015). The detector was not placed next to a waterbody (Figure 2). The surrounding area was forested and topographically rugged.

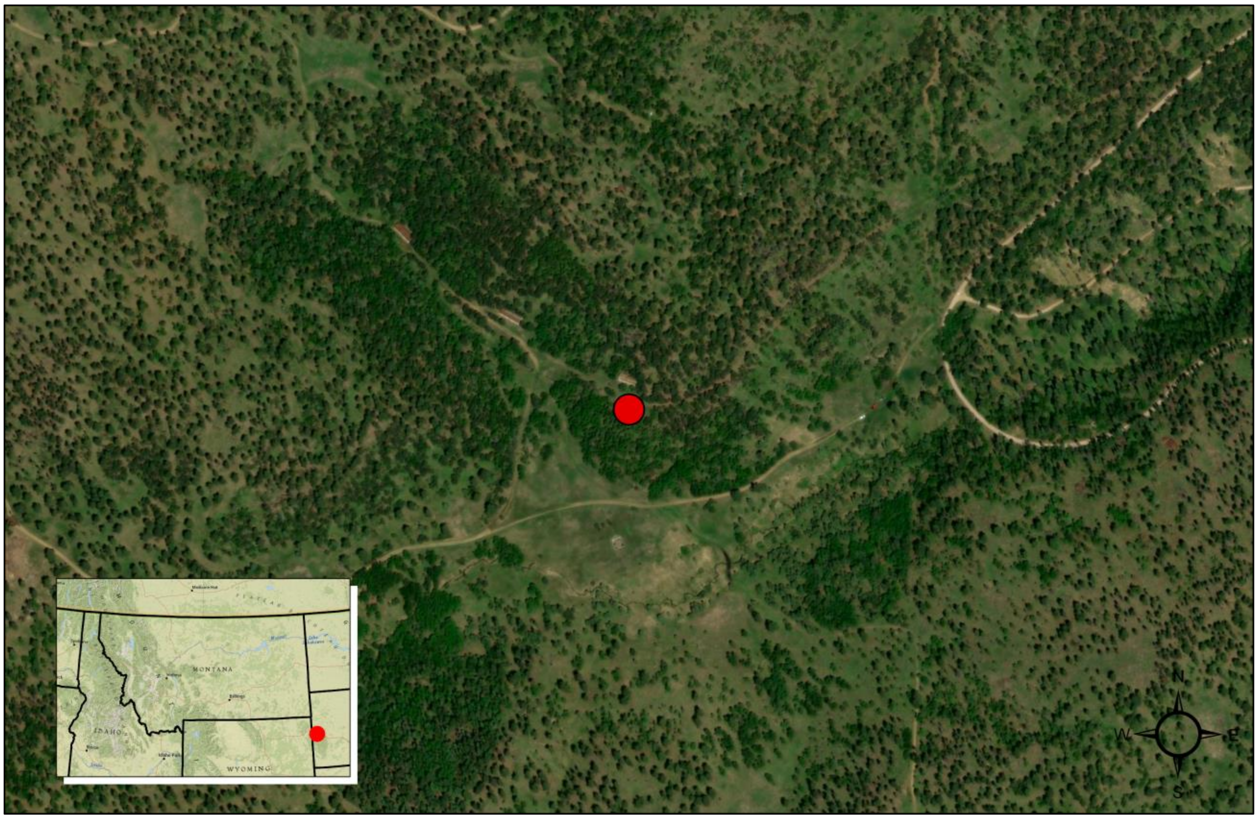

Figure 1. Placement of the Powderhouse detector.

A SM3 detector with a SMM-U1 microphone was deployed on 26 Jun 2015 and decommissioned on 02 Nov 2017, for a total of 861 nights deployed. Throughout the recording period the detector functioned well, recording on 851 nights or 98.8% of the time. In total this unit collected data over 30 months and met our minimum of 2 years of deployment for analysis of long-term trends.

Figure 2. Photo of the detector deployment site at Powderhouse.

Methods

Bat Detector Deployment

Across the acoustic network, detectors were placed at locations to maximize species diversity and bat activity through placement near features important for bats such as roosts, foraging areas, and waterbodies suitable for drinking. We assessed potential sites based on: (1) open water for as much of the year as possible; (2) rock outcrops and trees that might be used as roosts by bats; (3) southern solar exposure that would allow a solar panel to charge a battery even during the winter; (4) year-round accessibility; and (5) a low likelihood of vandalism. At all sites, a detector/recorder unit and microphone were deployed. The microphones at all operational sites in 2015 were upgraded to SMX-U1 microphones (Wildlife Acoustics Inc., Maynard, MA). The detector/recorder was deployed, monitored, and maintained with the equipment, supplies, settings, and protocols listed in Montana's Bat and White-Nose Syndrome Surveillance Plan and Protocols 2012- 2016 (Maxell 2015).

Many aspects of the equipment and site selections influenced the detection of a bat echolocation call and the quality of the resulting recording. These included sensitivity of the individual microphone, temperature, humidity, wind speed, and frequency, amplitude, distance, and directionality of echolocation calls emitted by bats (Parsons and Szewczak 2009, Agranat 2014). The energy of sounds spreading in all directions diminishes by one fourth for every doubling of distance because the surface area of a sphere is related to the square of its radius. Furthermore, higher frequency sounds are diminished over shorter distances because of atmospheric absorption (Parsons and Szewczak 2009, Agranat 2014). Testing of the SMX-US microphone used through June 2015 across the acoustic network indicated that bats emitting frequencies in the range of 20 kHz should be detected at distances of 24 to 33 meters from the microphone while those emitting frequencies in the range of 40 kHz should be detected at distances of 18 to 22 meters (Agranat 2014). These distances are the radii of the relevant spheres of detection around microphones when they are at full sensitivity. However, we know that sensitivity varied over time by an unknown magnitude because some precipitation and freezing events permanently reduced the sensitivity. In 2015 the microphones at active detectors were upgraded to the SMX-U1 microphone, which increased the quality of recorded calls and reduced the effect of adverse weather on microphone sensitivity over time. Due to this change in hardware, comparisons between data collected before and after June 2015 should be made with caution as the different models of microphone may affect the number of calls and species detected. Where applicable, individual reports for each unique equipment configuration were produced to minimize any interpretation errors.

Data Management & Call Analyses

Acoustic file recordings, in both original WAC and processed WAV formats, are stored in the Montana Bat Call Library which is housed on a series of 20-40 terabyte Drobo 5D storage arrays at the Montana State Library as well as a secondary offsite location to protect against catastrophic loss. Acoustic analysis results, temperature files, weather station data, and solar and lunar data were all processed and combined within SQL database tables in accordance with the general workflow pattern for data management and analysis outlined in the text and in Appendices 8-10 of Maxell (2015). Bat call sequences were analyzed with the goal of definitively identifying individual species presence by month and individual species' minimum temperatures of activity in accordance with the Echolocation Call

Characteristics of Montana Bats and Montana Bat Call Identification materials in Appendices 6 and 7 of Montana's Bat and White-Nose Syndrome Surveillance Plan and Protocols 2012- 2016 (Maxell 2015).

Weather Station Data

Weather station data were downloaded using the Mesowest application programming interface (API) as outlined in Appendix 9 of Maxell (2015). Temperature, wind speed, solar, and precipitation data were downloaded from weather stations across the regions. Distance from the detector to the station varied by site and data type. All data from weather stations were averaged by hour and associated with all call sequences recorded within this hour bin for use in our analyses.

Solar and Lunar Data

Solar and lunar data were calculated for all hours of detector deployment using the Python package ephem (3.7.6.0), which uses well established numeric routines to produce high precision astronomy computations (see Appendix 10 of Maxell 2015). The underlying code produces results nearly identical to data available from the U.S. Naval Observatory (Astronomical Applications Department). Precise times for sunrise, sunset, moonrise, moonset, and percent illumination at the detector were calculated based on latitude, longitude, and date. It should be noted that local topography is not incorporated into any of these calculations. Therefore, the exact timing of these events on the ground may differ slightly from those produced by this model but should typically be within a few minutes unless local terrain differs greatly from the modeled horizon (e.g. if the site is at the bottom of a canyon).

Results

Species at Site

During the deployment period, 30,261 call sequences were recorded at the Powderhouse detector. Of those, 12,058 (39.8%) were auto-identified to species and 316 were fully reviewed by hand. Of the 175 species-months with calls auto-identified to 13 different species, 34 species-months (19.4%) were confirmed by hand review for 8 species(Table 1).

Table 1. Species hand confirmed at the Powderhouse detector, by season. Species only observed previously and newly detected within the local area (50.0 km) are noted.

Species	Seasonal Presence	Acoustically Detected in Active Season	Acoustically Detected in Winter Season	Observed Previously, not Detected	New Species
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	Confirmed Year-round	Yes			Yes
Silver-haired Bat (*Lasionycteris noctivagans*)	Confirmed Year-round	Yes			Yes
Eastern Red Bat (*Lasiurus borealis*)	Migratory	Yes			Yes
Hoary Bat (*Lasiurus cinereus*)	Migratory	Yes			Yes
Western Small-footed Myotis (*Myotis ciliolabrum*)	Confirmed Year-round	Yes			Yes
Long-eared Myotis (*Myotis evotis*)	Confirmed Year-round	Yes			Yes
Little Brown Myotis (*Myotis lucifugus*)	Confirmed Year-round	Yes			Yes
Fringed Myotis (*Myotis thysanodes*)	Confirmed Year-round	Yes			Yes

General Patterns of Bat Activity

The patterns of activity recorded at the Powderhouse acoustic monitoring station were generally consistent with overall average bat activity patterns recorded across the regional network of acoustic detectors (Figure 3). During the active season, activity increased through the spring onto summer, peaked in July with an average of 3,218 calls recorded, and decreased in the fall. A monthly average of 863 calls were recorded between April and October. Activity during the winter was limited, with an average of 4 calls per month between November and March. February had the least activity, with an average of 1 calls recorded.

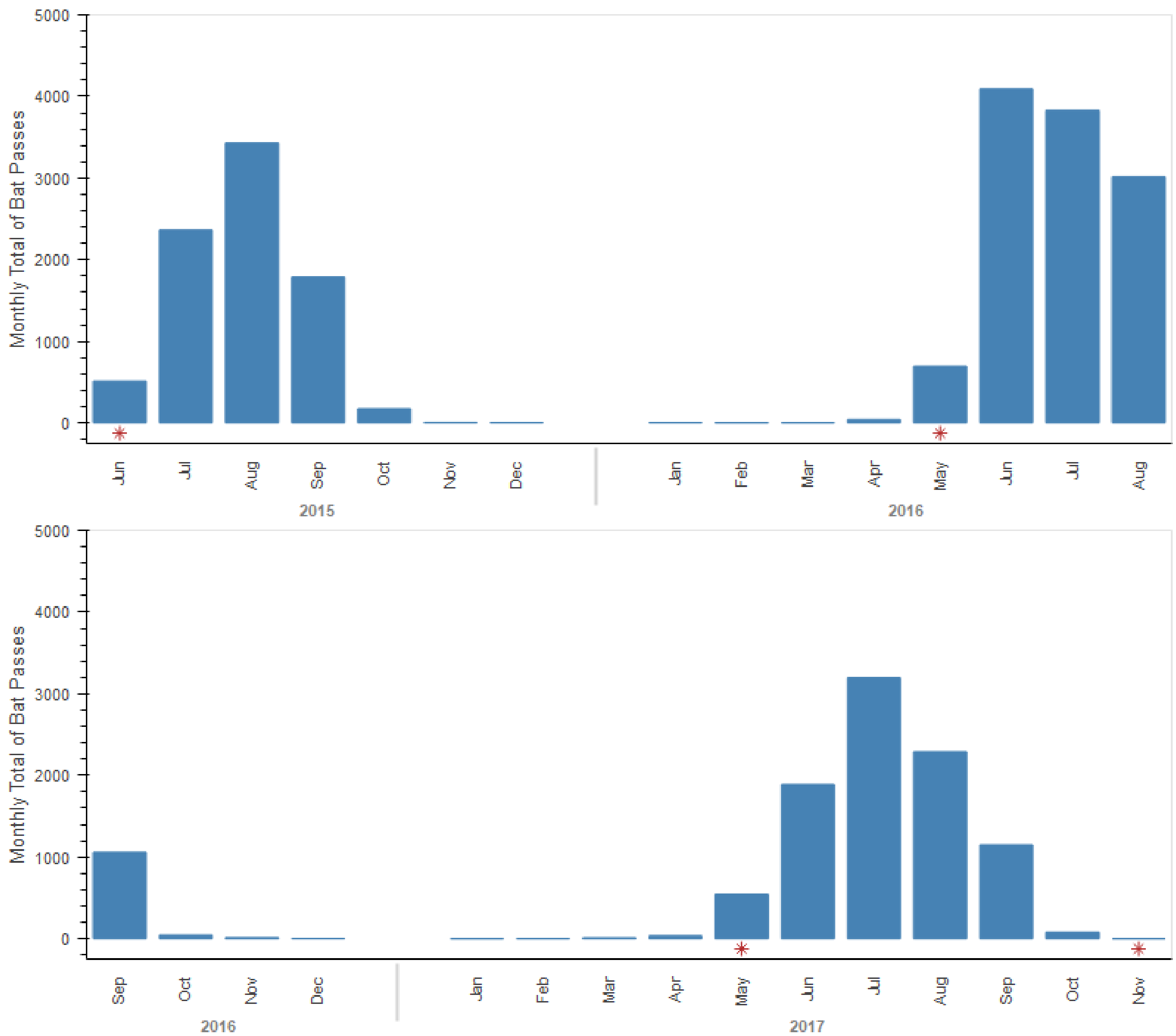

Figure 3. Total monthly bat passes recorded at the Powderhouse acoustic monitoring station. Months marked with an asterisk should be interpreted with caution as those data may not represent valid trend due to data collection for only part of that month, equipment malfunction or other issues.

Timing of Bat Activity

During the active season (April to October), some level of bat activity was evident throughout most of the nighttime hours. Activity often peaked immediately after sunset or close to sunrise. However, the pattern of activity varied across this period (Figure 4), likely in response to seasonal changes in the length of each night, prey availability, and physiological needs of the animals. Over the winter, the pattern of activity was less clearly tied to sunrise and sunset in most cases.

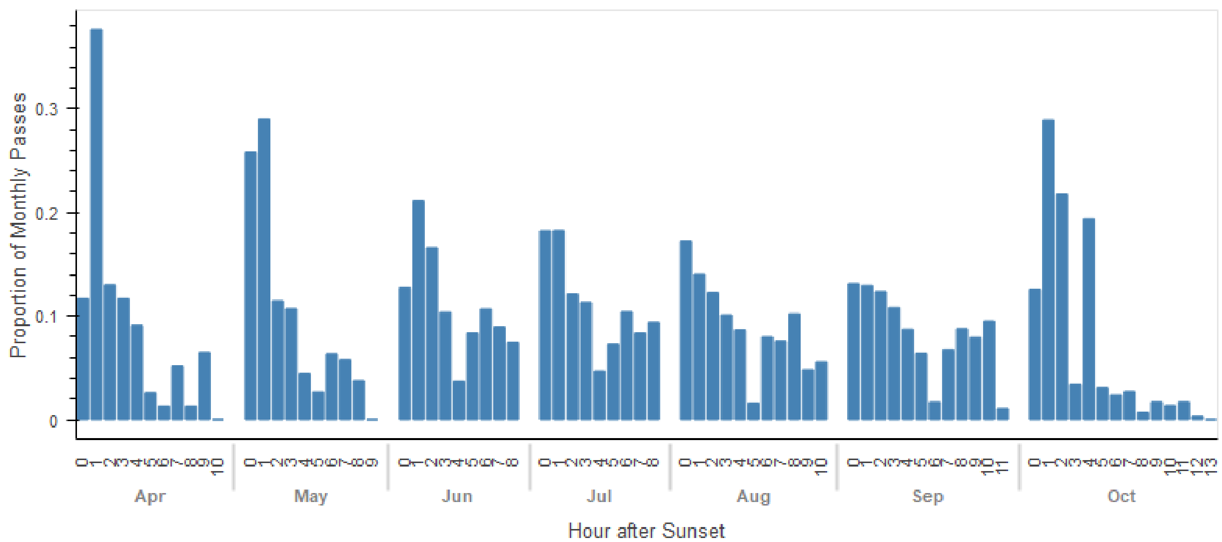

Figure 4. Average nightly activity of bats recorded at the Powderhouse acoustic monitoring station across the active season.

Temperature and Bat Activity

Throughout the study, average bat pass temperatures were generally higher than or equal to ambient nighttime background temperatures recorded at the detector (Figure 5). Bat calls were recorded at temperatures ranging from 0.25 to 28.25°C during the active season and -15.25 to 14.0°C during the winter season. Similarly, the distribution of temperatures recorded at the *ANNS2* station, located 9.1 kilometers to the west of the detector, that were associated with bat passes was significantly higher than the distribution of background temperatures (Figure 6). Thus, bats consistently restricted their activity to warmer time periods from the range of background temperatures available.

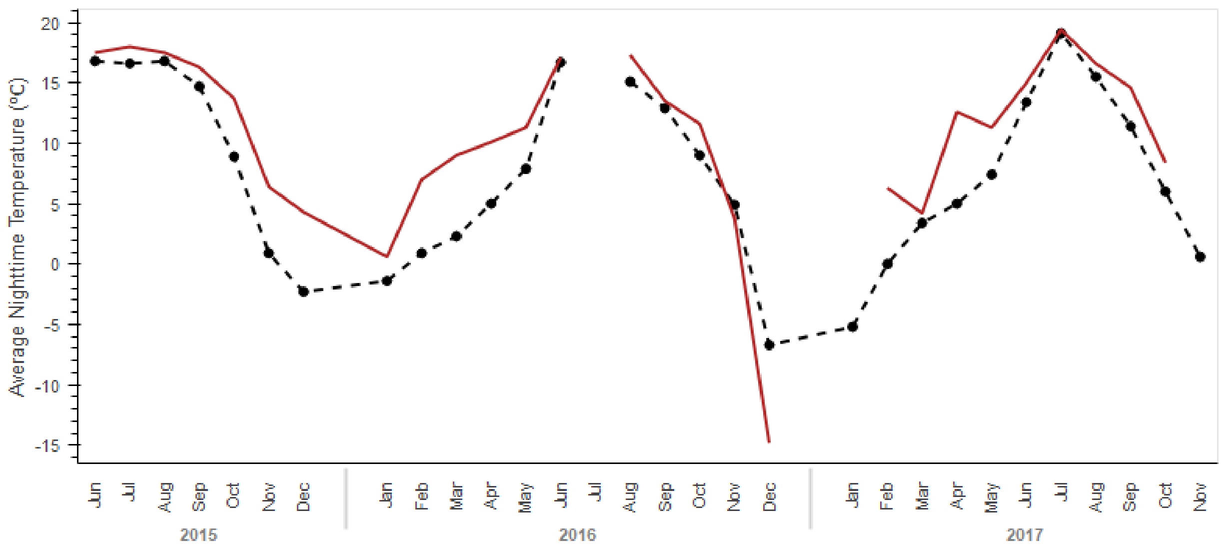

Figure 5. Average bat pass temperatures (red line) and average background temperatures (black line) across the year at the Powderhouse detector.

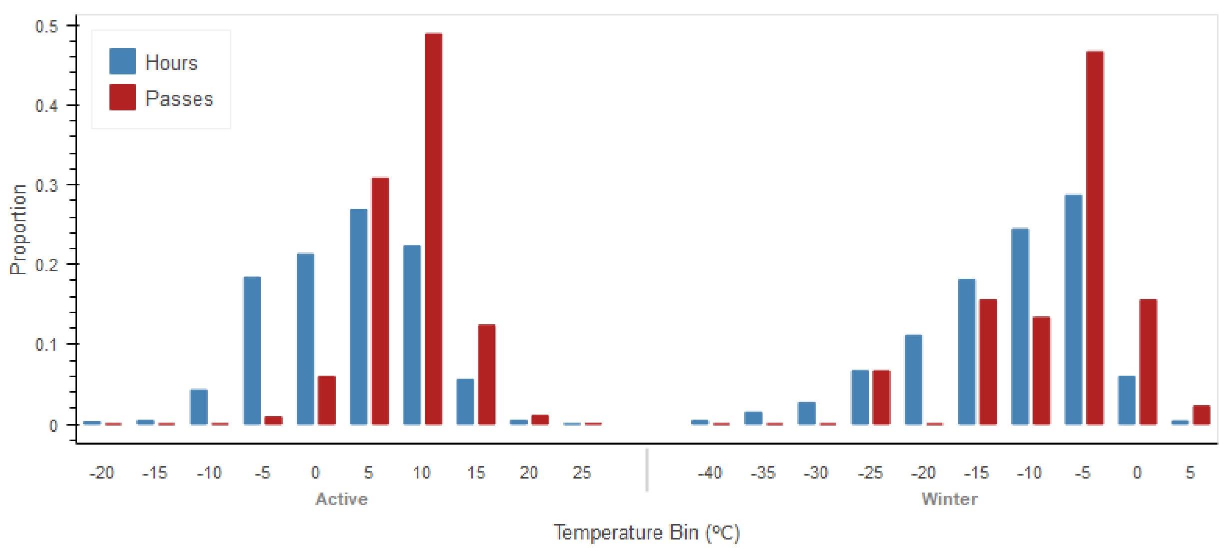

Figure 6. A comparison of average temperatures during bat passes (red) and average hourly background temperatures (blue) recorded at the ANNS2 station, located 9.1 km to the west of the detector. Where the bars showing passes exceed hours, bat activity is higher than expected for this temperature bin.

Wind Speed and Bat Activity

Bat activity patterns in relation to wind speed recorded at the *D2610* station, located 9.7 km to the south of the detector, indicate that 95% of activity was at windspeeds of 1.9 meters/second and below (Figure 7). Furthermore, bats were more active than expected at windspeeds of less than 1 meters/second (Figure 8). Due to the distance between the detector and the weather station and low bat activity in winter, the patterns shown should be interpreted cautiously (e.g. wind speed at the detector may not correlate with the measured wind speed).

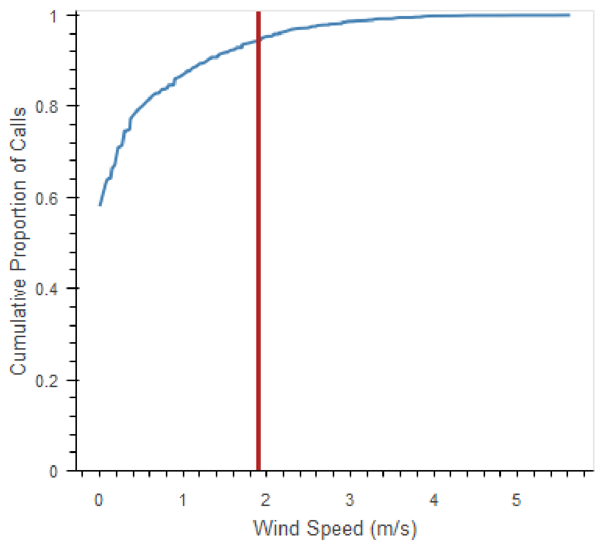

Figure 7. The cumulative sum of wind speeds recorded at the D2610 station during bat passes. The speed at which 95% of all activity occurs at or below is highlighted in red.

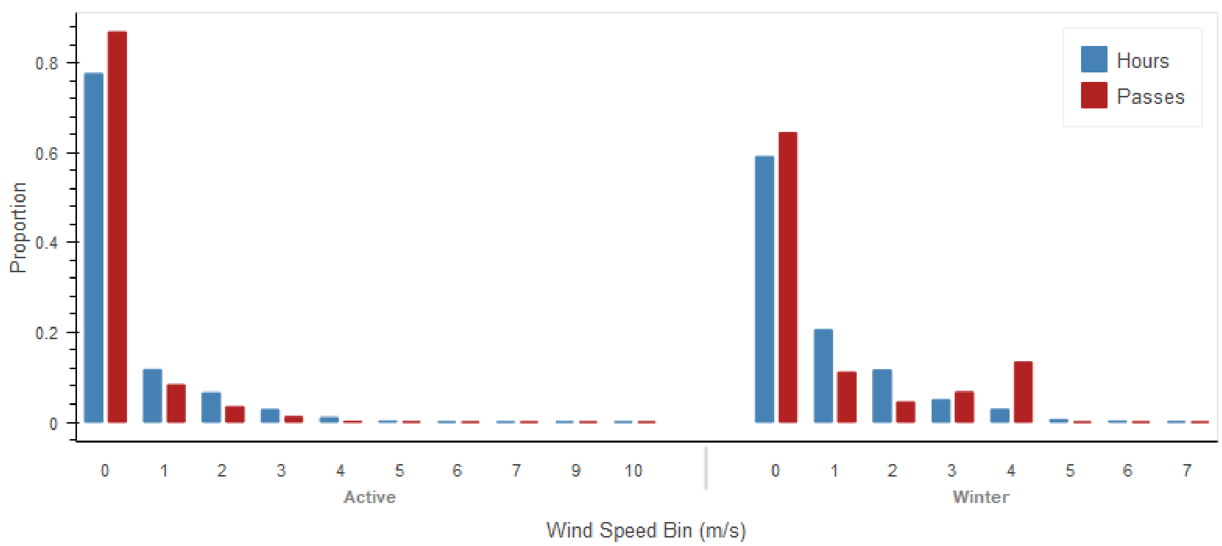

Figure 8. A comparison of background windspeeds recorded at the D2610 station (blue) and those recorded during bat passes (red). Where the bars showing passes exceed hours, bat activity is higher than expected for this wind speed bin.

Barometric Pressure and Bat Activity

Nearly 53.8% of bat activity was associated with little to no change (-0.5 to +0.5 millibars) in hourly barometric pressure recorded at the *D2610* station, located 9.7 km to the south of the detector (Figure 9). Bat activity was approximately equal to the availability of pressure change classes in the active season. During winter, bat activity was less than would be expected in the positive pressure change classes up to 4 millibars of change per hour in the winter season, which differs from most stations across the network. However, bat activity in the winter season is low and patterns shown may not be biologically significant.

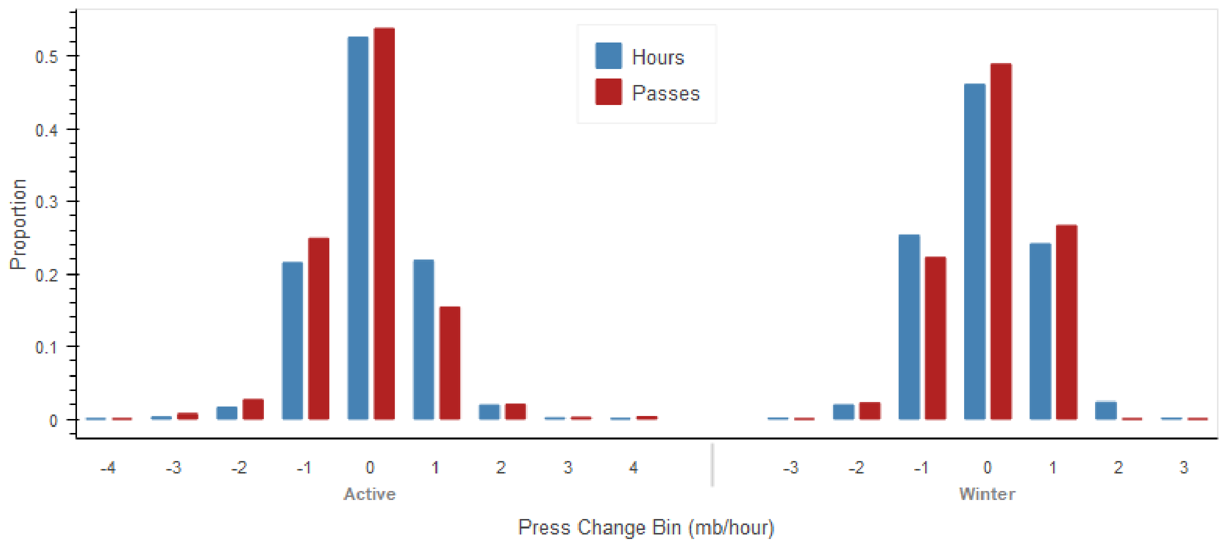

Figure 9. Hourly changes in background barometric pressure at the D2610 station (blue) compared to changes in pressure when bat passes were recorded (red) at the Powderhouse detector. Where the bars showing passes exceed hours, bat activity is higher than expected for this pressure change bin.

Precipitation and Bat Activity

At the Powderhouse detector, the distribution of bat activity was approximately equal to the distribution of hourly precipitation with no apparent selection for or against hours with precipitation. This may simply be a result of the facts that: (1) nighttime precipitation events are infrequent with only precipitation documented during only 4.7% of nighttime hours; (2) the *ANNS2* weather station is approximately 9.1 kilometers away and may not accurately represent precipitation at the bat detector, and (3) precipitation was coded in hourly bins while bats are capable of flight within minutes after the passage of a storm front.

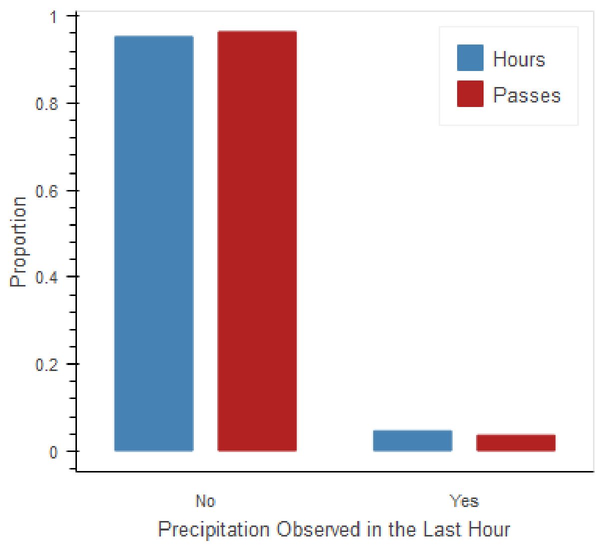

Figure 10. A comparison of hours with and without precipitation for bat passes (red) and all nighttime hours (blue) during the active season as recorded at the ANNS2 station, located 9.1 km to the west of the detector. Where the bars showing passes exceed hours, bat activity is higher than expected for this precipitation bin.

Moonlight & Bat Activity

At the detector site, bats were generally more active than expected during bright periods such as the full moon when the moon is predicted to be above the horizon (Figure 11). Generally, bats are less active during bright times, and at most sites across the network animals appear to be selecting for dark periods. The difference in behavior at this site may be due to the surrounding topography creating "light refugia" or areas that are relatively dark and provide animals the opportunity to forage in preferred environments.

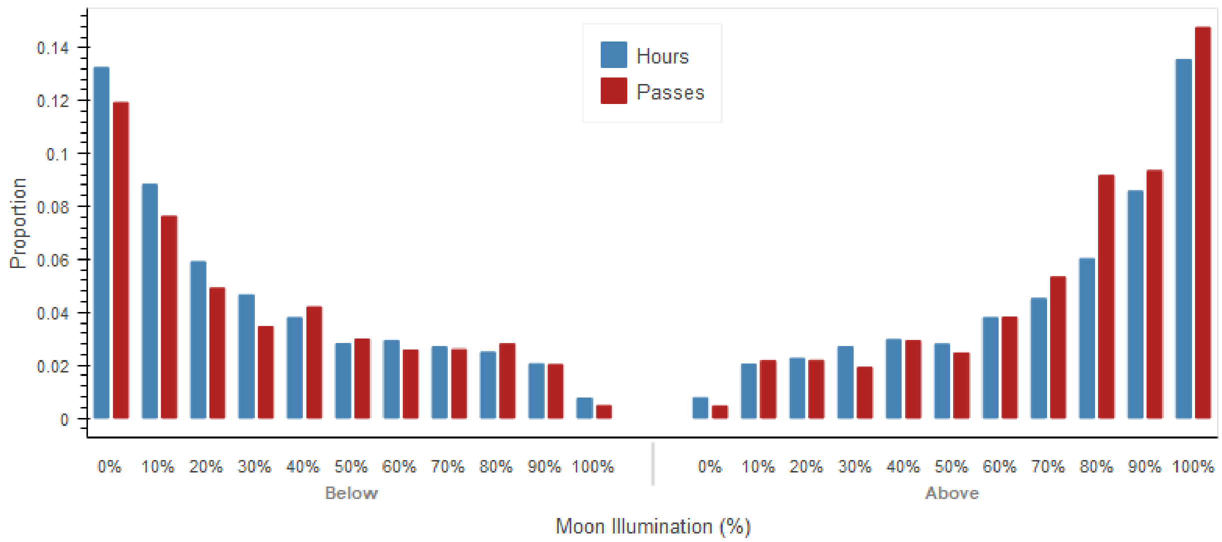

Figure 11. Percent of bat passes (red) and background hours (blue) at various moon illumination categories (0% = no illumination and 100% = full moon) and with the moon above and below the horizon. Where the bars showing passes exceed hours, bat activity is higher than expected for this moon horizon/illumination bin.

Species Activity Patterns

Identification of individual species activity patterns was hindered by relatively low and potentially inconsistent rates of auto-identification of call sequences to species (Table 4 in Maxell 2015). Only Little Brown Myotis, Long-eared Myotis, Fringed Myotis, Western Small-footed Myotis, Silver-haired Bat, and Hoary Bat had relatively high rates of confirmation of monthly presence, enough calls auto-identified to examine trends, and >50 percent correct auto-identification rates of call sequences of known species identity in the Montana Bat Call Library (Table 2). For those 6 species at this site with high auto-identification confirmation, potential patterns of documented activity are shown in Figure 12. However, activity patterns for these species from auto-identified call sequences should still be regarded as speculative due to a variety of issues that might cause auto-identifications to be inaccurate and/or inconsistent (Maxell 2015).

Table 2. The number of months each bat species was confirmed by hand analysis of calls identified by automated software, the number of months reviewed, and the respective successful classification rate; only active season data are shown.

Species	Months Confirmed	Months Reviewed	Auto-Identification Success Rate
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	5	5	100.0%
Big Brown Bat (*Eptesicus fuscus*)	0	19	0.0%
Spotted Bat (*Euderma maculatum*)	0	2	0.0%
Silver-haired Bat (*Lasionycteris noctivagans*)	7	18	38.9%
Eastern Red Bat (*Lasiurus borealis*)	2	4	50.0%
Hoary Bat (*Lasiurus cinereus*)	9	13	69.2%
Western Small-footed Myotis (*Myotis ciliolabrum*)	5	9	55.6%
Long-eared Myotis (*Myotis evotis*)	2	12	16.7%
Little Brown Myotis (*Myotis lucifugus*)	1	2	50.0%
Northern Myotis (*Myotis septentrionalis*)	0	8	0.0%
Fringed Myotis (*Myotis thysanodes*)	3	9	33.3%
Long-legged Myotis (*Myotis volans*)	0	8	0.0%

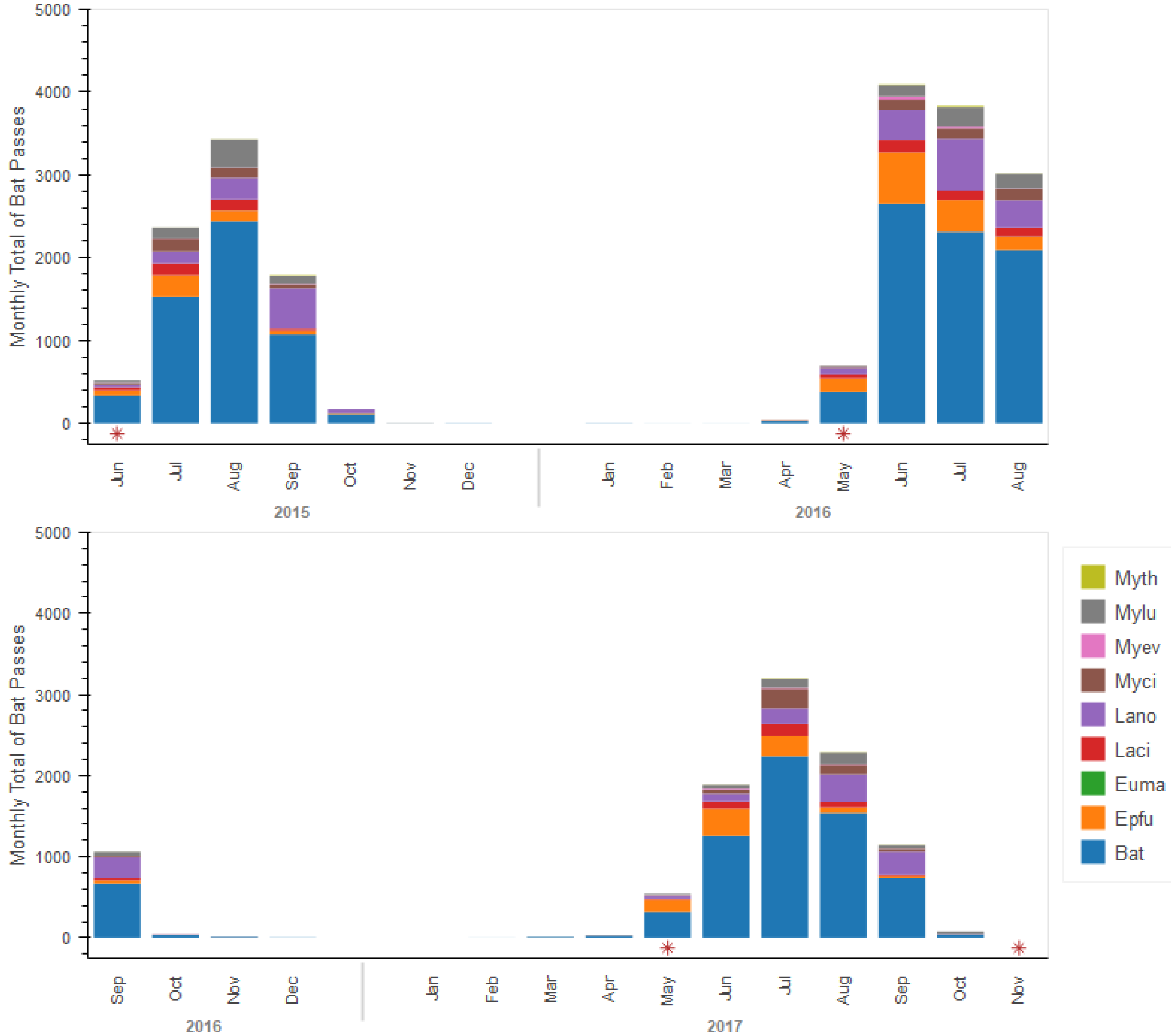

Figure 12. Bat passes through the deployment period identified to species using SonoBat 4.1. Note that these species identification are only suggestions and should only be used to assess general trends for species for which the classifier works well.

Discussion

At this detector we confirmed the presence of 8 species (Table 1). Of the species documented, there were 0 Species of Greatest Conservation Need (SGCN). No confirmed species are currently listed as threatened or endangered by the U. S. Fish and Wildlife Service (USFWS). The state and federal conservation or regulatory status for observed species are listed in Table 3.

Species presence and activity metrics recorded at these sites will serve as robust baseline that can be used to assess the status of populations at sites into the future. This is particularly important due to the imminent threats to bat species posed by White-Nose Syndrome (WNS) caused by the pathogenic fungus *Pseudogymnoascus destructans* (*Pd*) and wind energy development. During this deployment, 26 of 30 months recorded met our standards for quality. As such, our assessment is that sufficient data have been collected to document bat activity and species diversity at the site during this time period.

Listed Species Conservation

In South Dakota, the Northern Myotis (*Myotis septentrionalis*) is the only bat species listed by the USFWS as threatened or endangered. The USFWS has designated 9 counties along Montana's eastern border and North and South Dakota as within the range of this species, and the species has been confirmed as present within three Montana counties (MTNHP 2020). This detector was deployed at a site within the range for this species. Across the recording period, the auto-classifier found 91 call sequences that had characteristics similar to those produced by Northern Myotis. Of these, 21 were potentially made by this species although none could be hand verified as definitively Northern Myotis. Based on this hand review of auto-classified sequences, we have determined that the species may be present. To confirm the species presence, additional surveys should be conducted including mist netting with genetic confirmation of all captured animals identified as or suspected to be Northern Myotis.

White-nose Syndrome

To-date, the presence of *Pseudogymnoascus destructans* and associated WNS have not been detected in Montana. However, *Pd* and WNS was detected in Washington in 2015 (WDFW, USFWS, and USGS 2016) and in South Dakota and Wyoming in 2018 (NPS 2018, WYGFD 2018). These detections and the continued spread westward into the Great Plains have increased the urgency for establishing baseline metrics to assess future impacts on resident bats. Of the 8 species detected at this site, 2 have been shown to develop WNS when exposed to *Pd*. These species are Long-eared Myotis and Little Brown Myotis (Table 3). Additionally, Townsend's Big-eared Bat, Silver-haired Bat, Eastern Red Bat, and Western Small-footed Myotis have been shown to carry *Pd*, but not exhibit symptoms of WNS (Bachen et al. 2018, but see WhiteNoseSyndrome.org for most up to date information on species susceptibility). The remaining *Myotis* species have not been shown to carry *Pd* or develop WNS. Rather than indicating immunity, the lack of detections of *Pd* positive individuals or WNS is likely a result of their western distribution that does not overlap affected areas. As many other *Myotis* species are impacted by WNS, it is probably best to consider these species as susceptible until proven otherwise.

Through the deployment of this and other detectors across the network, we now know that winter activity is normal for many resident bat species and does not necessarily indicate the presence of *Pd* in the local area. At this detector we found that winter activity was in the second quartile (25-50%) of

average activity recorded across network sites. We were unable to confirm the presence of any species during the winter season at this site (Table 1).

Wind Energy Development

Tree roosting species such as the Eastern Red Bat, Hoary Bat, and Silver-haired Bat are not known to be susceptible to WNS but suffer mortality at wind farms. Of these we detected Eastern Red Bat, Hoary Bat, and Silver-haired Bat at the detector site. Due to the presence of these species, mortality due to wind energy is a concern for this area at current and future sites. These species often fly near turbines and suffer barotrauma when near the turbine blades. Due to these species low reproductive rate and long life, unmitigated wind energy development may cause precipitous declines of these species over the next 50 years (Frick et al. 2017). Wind energy may have indirect impacts on bats using this site due to mortality during migration or decreased regional populations. If development of wind energy is considered within the local area, mitigation measures should be implemented to reduce potential impacts on resident and migratory species.

Table 3. Management considerations for species detected within 50.0 km of the Powderhouse detector. Species presence is summarized by season and include this and any previous efforts.

Species	Seasonal Presence	Detected Active Season[1]	Detected Winter Season[2]	State Status (South Dakota)	Federal Status	White-Nose Syndrome Impacts[3]	Wind Energy Impacts[4]
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	Confirmed Year-round	Yes		SGCN-3	BLM - Sensitive/USFS - Sensitive	Detected - Possibly Susceptible	No Mortality Documented
Silver-haired Bat (*Lasionycteris noctivagans*)	Confirmed Year-round	Yes		SGCN-3		Detected - Possibly Susceptible	Frequent Mortality Documented
Eastern Red Bat (*Lasiurus borealis*)	Migratory	Yes				Detected - Possibly Susceptible	Frequent Mortality Documented
Hoary Bat (*Lasiurus cinereus*)	Migratory	Yes				No impacts	Frequent Mortality Documented
Western Small-footed Myotis (*Myotis ciliolabrum*)	Confirmed Year-round	Yes				Detected - Likely Susceptible	No Mortality Documented
Long-eared Myotis (*Myotis evotis*)	Confirmed Year-round	Yes				Confirmed Susceptible - Mortality Documented	No Mortality Documented
Little Brown Myotis (*Myotis lucifugus*)	Confirmed Year-round	Yes				Confirmed Susceptible - Mortality Documented	Infrequent Mortality Documented
Fringed Myotis (*Myotis thysanodes*)	Confirmed Year-round	Yes		SGCN-2a	BLM - Sensitive	Likely Susceptible	No Mortality Documented

[1]may indicate day roosts and/or maternity colonies present in area
[2]may indicate hibernaculum or other important winter habitat in area
[3]see review in Bachen et al. (2018) and WhiteNoseSyndrome.org
[4]see review in Bachen et al. (2018)

Management Recommendations

Measures of overall bat activity near the detector, hand confirmed presence of individual species by month, and hand confirmed minimum temperatures associated with bat passes of individual species are all stable metrics upon which management recommendations can be made. However, patterns of activity of individual species resulting from automated analyses should be used with a great deal of caution due to low rates of species assignment and low or uncertain rates of accuracy of those assignments. Furthermore, it should be noted that bat activity measured during this study was made by a microphone on a nine to ten-foot mast and may not have adequately sampled the activity of high flying bats such as the Hoary Bat and Silver-haired Bat, which together with the Eastern Red Bat are the three species that have suffered approximately 75% of the documented mortalities associated with wind turbines across North America (Kunz et al. 2007). Thus, the following management recommendations avoid use of activity patterns of individual species as determined by automated analyses and instead rely on results of hand confirmed analyses, general patterns of bat activity that were recorded at the study site, and results of published studies of wind turbine impacts on bat species.

General management recommendations for species observed at project sites include:

(1) Protect potential natural roost sites by conserving large diameter trees (especially snags with loose bark), rock outcrops, cliff crevices, and caves.

(2) Maintain accessibility for underground mine entrances that bats may be using as summer or winter roosts. Install bat friendly gates if closure is required.

(3) When removing bat colonies from buildings or other structures follow current best practices, including waiting until the late fall and winter to seal entry points and placing bat houses to compensate for elimination of the roost.

(4) Reduce structural complexity of vegetation (e.g., short stature grasslands) and availability of standing waters in proximity to wind turbines or other human structures that might represent a threat to bats or where bats are undesired.

(5) In safe environments, maintain lotic or lentic waterbodies to provide habitat for foraging and drinking.

(6) If wind turbines are installed in the region, set turbine cut-in speeds to > 6.0 m/sec between April and October – especially important in July during peak bat activity when young are newly flighted, and August, September, and October when migratory species are passing through and local bats are swarming and breeding. Feather wind turbine blades, making them parallel to wind direction, when wind speeds are <6 m/sec to reduce risk of barotrauma during times of relatively high bat activity.

(7) Report dead bats of any species found in the winter or spring to Montana Fish Wildlife and Parks or Montana Natural Heritage Program personnel. Animals found dead during these seasons may have contracted WNS and should be tested as part of Montana’s Passive WNS surveillance protocol.

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